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ABSTRACT

A British project: (1) identified national needs for continuing education and training (CET) in new materials; (2) assessed the priorities among the needs and developed course outlines; and (3) established a CET needs review system for training in new materials. The new materials fall into four categories: (1) polymers; (2) composites; (3) advanced ceramics; and (4) metal alloys. A questionnaire was completed by 85 percent of a representative cross-section of British industry regarding their participation in continuing education. Visits were then conducted with 56 respondents. The subjects requested instruction in 12 course subject areas: ceramics; new materials; management of technology; composites; business methods; environment; design; metals/alloys; adhesives; surfaces; languages; and computer modeling. Information on courses and conferences was obtained from several comprehensive directories. The survey shows that 165 courses were available over the 2-year period from 36 universities and professional institutions. (Twenty-three references, 10 tables, and an appendix listing discussion topics for site visits are included. Table 10 provides an outline of short courses. Course name, interested industry, description and application, level, and outline content of course are provided for 41 courses.) (NLA)

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Continuing Education in New Materials

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Continuing Education in New Materials

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Foreword

This document is a summarised report of a project undertaken by Dr Angela Gunning under the direction of Professor Roland Clift of the University of Surrey. The project was initiated jointly by the Institution of Chemical Engineers and the Institute of Metals.

The aims of the project were to:

- identify national needs for continuing education and training (CET)* in new materials;
- assess the priorities amongst these needs and develop course outlines to satisfy the most urgent needs;
- establish a CET needs review system for training in new materials.

This is the latest FEU/PICKUP publication in the field of CET, and also relates to FEU work in Key Technologies (see *The Key Technologies - some implications for education and training*, FEU/Engineering Council, 1988). The importance of teamwork in engineering and science was emphasised in *The Concept of the Key Technologies* (FEU, 1989) in addition to technical knowledge and ability. It is interesting to note that the current research reinforces this point by identifying a need for European 'language' and 'business methods' training and recommends 'interchange amongst peers' as a valuable part of the delivery of any CET programme.

The institutions which sponsored this project have access to the original draft of this report, and have begun to implement some of the recommendations. Upon request, these institutions will provide details of work-in-hand.

FEU would like to thank the two professional institutions, Roland Clift, the members of the steering committee, and most of all Angela Gunning for her professional approach to the project and for a report that was well written and presented.

Additional material relating to the full report may be obtained from the FEU Information Office.

Albert Clyde
Development Officer

*CET is often referred to as CPD (continuing professional development).

Introduction

Science and technology do not stand still at the moment of graduation. Research, development and production are continually evolving. So, how do postgraduates keep informed of the latest developments in their field? And why should they?

The science of materials has developed and expanded rapidly during the past 20 years. New materials have been developed, tested and assimilated in the manufacture of products. Their success has been variable. Some are genuine improvements and new applications, others have been over hasty replacements and substitutions resulting in a bad reputation for the industry.

What are these new materials - indeed what were the old materials? To define either is hard - one might say 'you know them when you see them'! Very roughly, old materials are those known about and reliably used up to 1965. New materials have been invented and/or developed, or even simply applied since then. Often the longest step a new material takes to reach the consumer is in the development of large-scale industrial processing technology.

The new materials fall into four categories:

- polymers and plastics
- composites
- advanced ceramics
- metal alloys

The application of these materials brings with it additional new technologies - design and testing methods, different or unknown hazards in the workplace, waste disposal problems, long-term effects on the environment, the need for new fabrication skills and machinery, and different joining technologies. In a wider context, there is consumer education (both domestic and industrial) to ensure confidence and acceptance. There are also economic implications related to the introduction of a new material — particularly where it replaces a material with well-established credentials.

This is a rapidly changing field; those working in it must continually update their knowledge, not just about the materials but about the practices of competing companies and institutions.

This project is about continuing education and training (CET) in new materials. What is CET? It would have been easy to assume that 'continuing education' meant 'more education' in the conventional form of school and college. But

there are other ways of learning technical, scientific and commercial facts. Are they preferable; are they effective? This project examines not just what the materials industry needs, but also seeks to identify the preferred and most effective methods of assimilation of the appropriate information.

Education and training in the emergent technologies have received increasing interest and study in the past decade. In 1980 the Finniston report (1) highlighted the need for more and better trained scientists and technologists. The Collyear report (2) looked at the implications of the resource gap for the new and improved materials industry. There have also been studies of the materials industry and the field of CET - in advanced ceramics (3), in plastics, composites and adhesives (4), and the 'key technologies' (materials, components, manufacturing and process) (5). Each of these studies looks at a different aspect of the problem and the conclusions are concurrent; namely, there must be more graduates in the materials sciences, more investment in the materials industries, more application of the new materials and more CET to back all this - **if** UK industry is to remain viable and competitive in world markets.

Colleges of Further and Higher Education (FHE) have investigated local needs for materials education (6, 7). 'Local collaborative projects' cover all levels of ability, including development of the necessary craft skills. Other studies have revealed wide knowledge gaps (8, 9, 10) in the application and use of materials and towards CET in general. In addition there were conferences during 1988/89 on the subject of CET in new materials (11, 12, 13). The Department of Trade and Industry (DTI) has, with the assistance of the Design Council, funded the 'PROMAT' initiative to promote interest in the use of new materials in industry (14).

At the other end of the spectrum various colleges, polytechnics and universities are developing technician and undergraduate courses to meet the shortcomings which industry perceives in current materials courses (15, 16, 17). The Science and Engineering Research Council (SERC) initiative (18) of the Integrated Graduate Development Scheme (IGDS) now includes materials-related modules in some of its courses, e.g. at the University of Newcastle upon Tyne.

Other positive initiatives are emerging. The National Centre for Composites in Birmingham plans to offer CET facilities in composites. The Design Council is developing a data base in materials information and publishes its annual directory of short courses (19). The Engineering Council is working to encourage much greater take-up of CET post graduation (20), and has launched a pilot scheme called 'Career Action Plan', in which participants enter details of their career development in a special diary (the 'Career Manager').

Questionnaire

The study began with a survey by postal questionnaire which was designed, in both content and layout, to maximise interest and response. The questions were short, relating mainly to fact rather than opinion and required yes/no replies. A covering letter, personally addressed, explained the purpose of the project and asked whether a follow-up visit would be welcome.

The questionnaire takes the reader through questions relating to his/her present situation - position, activity, skills. The next part introduces 'new materials' and asks for specific information about perceived needs in CET. The last part deals with self-awareness and learning preferences.

Target samples for questionnaire

The recipients of the questionnaire were chosen to be a representative cross-section of UK industry and included large and small manufacturers and users of new materials.

These industries included transport, aerospace, food, adhesives, equipment, research establishments, manufacturers of composites, ceramics, metals. Over 160 questionnaires were sent to 96 different companies - to named individuals - together with a personally addressed introductory letter which explained the purpose of the project.

The number of individuals approached in each type of industry was in proportion to the relative number of graduates with materials-related occupations in that industry.

The project sought personal opinions and preferences in CET rather than making a compilation of company policies as it is usually the individual who decides what events to attend. The questionnaire asked the recipient about willingness to participate in further discussions, and whether other colleagues could be invited to attend.

Analysis of responses to the questionnaire

Fifty-eight per cent of questionnaires were completed, and a further nine per cent were returned with a covering letter explaining why the respondent did not wish to participate in the project. The distribution of replies amongst the various industries matched that of the initial sample. All results quoted are expressed as a percentage of the number of questionnaires returned (Y).

Table 1: Acquisition of present knowledge of materials

	as % of Y
postgraduate research	48
short courses	20
in-company course, lecture or scheme	12
on-the-job training	35
technical literature	75
attending conferences and seminars	75
job changes	27
primary qualifications	18
other	5

PARTICIPATION IN CONTINUING EDUCATION

The replies to Question 3 revealed how the respondents had acquired their current knowledge and skills relevant to 'new materials', since 69% did not have an initial qualification in a materials subject. Table 1 shows these results, as a percentage of Y (the number of questionnaires returned), with the use of published technical literature and conferences/seminars being the most common methods (each 75%).

MATERIALS-RELATED WORK

Table 2 shows the respondents' materials-related work activities. However, an insight into the system of recognition and promotion in UK industry is given by the fact that although most respondents worked in research, design and development sectors, some 70% described their activities as 'management'.

Table 2: Job description of respondents

	*as % of Y**
fundamental research	35
design	15
development of a product	56
development of a material	47
development of production techniques	24
testing/safety/hazards	9
manufacturing	10
feasibility/statistical work	3
market research	4
marketing and sales	15
training and education	1
management	57
finance	2

* total exceeds 100% as up to three choices permitted.

Question 5 related to the materials that the respondents worked with. Table 3 shows the results, as a % of Y.

Table 3: Materials with which respondents mainly work

	*as % of Y**
thermoplastics polymers	52
thermosetting polymers	44
rubbers	23
elastomers	24
synthetic membranes	13
high conductivity polymers	10
adhesives and joining technology	42
polymer matrix composites	47
metal matrix composites	33
engineering ceramics	40
steels	31
light alloys	11
high temperature alloys	27
device materials	15
rapidly solidified materials	18

* total exceeds 100% as multiple choices permitted.

SUBJECT INTERESTS IN NEW MATERIALS

In Question 6 respondents were asked in which subject areas they felt CET would assist their professional development. The most frequently cited subject was composites - 33%. Ceramics was second with 23%, and polymers and alloys jointly third with 22%. Table 4 shows the order of preference for each of these key areas for particular subjects.

Table 4: Subject areas in which respondents thought CET would assist their professional development - given in decreasing order of mention

Polymers/ plastics	*Composites*	*Ceramics*	*Alloys*
Product development	Product development	Product development Properties	Product development
Properties Processing technology	Processing technology Properties	Corrosion Processing technology	Corrosion Properties Surfaces Joining *
General introduction Corrosion	Joining technology Corrosion	Joining technology	Processing technology General introduction
Joining technology Surfaces	General introduction	General introduction	Marketing
Environment	Marketing Surfaces	Marketing	Detailed introduction
Marketing Detailed introduction	Environment	Surfaces	Environment
—	Detailed introduction	Detailed introduction	—
—	—	Environment	—

* the) symbol represents equal preferences.

The relatively low interest in joining technology and adhesives shown in the previous table does not reflect the interest shown in the interviews or the high number of respondents actually working in this area (42%).

Visits

The questionnaire was designed to elicit quantifiable information from the respondents, using short, unambiguous questions. However, further information of a more qualitative, subjective nature was also required from respondents - their feelings and opinions about continuing education. The method chosen to obtain the data required was a personal visit with a structured conversation. A framework for the conversation was prepared, to ensure that key points were covered and minuted in an orderly manner. (The appendix shows the content of the proposed guidelines.)

This format proved an efficient method of keeping the discussions closely in line with the subject area, and greatly assisted in collating the results. Conversations were also kept within a projected time limit of 80-90 minutes.

Forty-five companies were visited and 56 respondents were interviewed. The conversations encouraged the respondents to give their preferences and ideas in their own words, without leading suggestions. Their comments were frank and perceptive, with many constructive suggestions for improving and extending continuing education in the field of new materials.

Analysis of visits

In the course of these interviews a significant number of respondents (30%) claimed to be 'leaders in the field'. One commented 'who could teach us anything?' Of these 'leaders', 30% gave courses, or contributed to the courses run by others. Another 30% also did this, but did not claim such supremacy.

Table 5 shows the opinions of those interviewed, when asked 'What is CET for?'

Table 5: 'What is CET for?'

	% of those interviewed
to make contacts	76
keep up to date	67
good for business	58
ideas	9
promotion	9
flexibility	9

Most interest in CET is passive, i.e. respondents will look through journals for forthcoming events in their field. Few actively sought events to meet a need they had identified. In scanning publications which advertise events, the individuals will have certain criteria for the mode of CET they select. From the interviews, the general consensus is:

Courses are for specialist and practical skills for young people where they gain a lot of specialist knowledge in a short time; and study subject-matter one might have learnt in a first degree course.

Conferences/ Seminars are for providing the latest information about current events and developments; for seeking ideas and observing trends.

Possibly rather obvious observations, but since this project is looking at CET needs, it is essential to separate needs from wants, and to make recommendations which will satisfy those needs.

YOUNG PEOPLE

Half of those interviewed were concerned that recent graduates should be given every opportunity to continue their education. Most departments operated a budget for attendance at CET events taking place outside the company. Seniority inevitably played some part in the decisions as to who could (or should) attend events. Since getting the best out of a conference or seminar is an acquired technique some companies have the policy that young people are 'escorted' to such events so that they can learn how to profit from them. However, of the young people interviewed, half of them commented that 'it's older people who get to these events'.

The capability and depth of knowledge of new graduates concerned many heads of department or those in the middle age-band (35-50) who said it was difficult to recruit the right type of person. This they defined as one who is fundamentally well educated, able to think and to undertake research. New graduates crammed with information are not what is required. The characteristics sought in young recruits are, in decreasing order of frequency of mention:

- good basic knowledge of fundamental scientific principles
- flexibility, innovativeness and adaptability
- good grounding in materials science
- a better appreciation of industry
- more maths and engineering

Eleven per cent of the companies visited were participating in Teaching Company schemes, and found this a good way of integrating young researchers into the company. However, in discussions about recruitment of graduates, 38% said that salary was a major problem.

COURSE SUBJECT AREAS

To establish in which subjects the New Materials industry needs CET, interviews were structured so that the interviewees could express what they, and their department/company needed for future prosperity - or even survival. Nor did the questionnaire ask directly for 'course subject preferences'. Question 6 asked 'which areas in CET would assist your professional development?' However, there were many more working in the areas of composites, adhesives and metals than indicated an interest in CET in these subjects.

The subjects mentioned and/or requested during the interviews are listed below in decreasing order of frequency of mention:

1. CERAMICS

Nearly one-third raised the subject of the need for more CET in Ceramics. This was expressed variously in terms of fibres, corrosion, properties, user education, and more about advanced ceramics.

2. NEW MATERIALS

The introduction or 'substitution' of new materials in existing applications, and into new applications is an area of great interest. It covers the technicalities of fabrication, training for new skills, education of consumers, new machinery and the economics of investment and change.

3. MANAGEMENT OF TECHNOLOGY

Notwithstanding the general preoccupation with management, particular skills for technology and research management were specifically mentioned. The arts of trend-spotting and honing recruitment methods were also included.

4. COMPOSITES

The same number of people raised the subject of CET in composites during the interviews as in the questionnaire. Two-thirds of those working in the composites field were visited. Interviewees were not specific about the aspects of composites in which they wanted CET.

5. BUSINESS METHODS

Interviewees wanted to know about the intricacies of negotiations and contracts, trading in Europe, standards in USA, exporting to the Third World (food in particular) and Euro-funding for Research and Development (R&D) projects.

6. ENVIRONMENT

There were more mentions of environmental issues during the interviews than in the questionnaire. Safety at work, disposal of wastes, product liability, hazardous materials were areas where a lot more information and training could be used.

7. DESIGN

The integration of design with materials has been the subject of other detailed studies (10). While many of those interviewed recognised the problems of introducing new materials into production lines and new products, the fundamental relationship between materials and design has not received much attention from the materials scientists.

8. METALS/ALLOYS

One-third of those who replied to the questionnaire were working in metals, and two-thirds of these were interviewed. Even so, many more respondents to the questionnaire wanted CET in metals and alloys than raised the subject in interview. The areas of interest were titanium alloys, precious metals, tin-free steels, semi-conductors and single crystal films.

9. ADHESIVES

Forty-two per cent of the questionnaire respondents work in adhesives. The economics of change from conventional joining technology to adhesives is the main area of interest.

10. SURFACES

Detailed knowledge of Surfaces Science featured low in the CET priorities - and the interview results are consistent with this finding.

11. LANGUAGES

Many of those interviewed expressed support for the idea of learning a foreign language, and a few actually suggested that an academic institution or professional body should provide such courses. One or two companies were planning to have intensive customised language courses, to be held in house.

12. COMPUTER-MODELLING

The development of new fabrication processes for new materials often benefits from computer-based modelling techniques. A few interviewees specifically raised the need for more, relevant CET in this area.

Continuing education available and critique

METHODOLOGY

Courses in new materials available in the UK in 1988 and 1989 were surveyed. (Courses covering subject matter relating to conventional materials were excluded.) In analysing their content, the courses were classified into 'subjects' according to the table in Question 6. Where a course covered more than one

subject or material, it was counted each time, since it would satisfy each subject indicated by a respondent in the questionnaire replies. The two-year time span was used in order to match the replies to Question 4, which dealt with respondents' participation in CET.

A secondary survey was made of world-wide conferences on materials, advertised in the UK in 1988 and 1989.

Information on courses and conferences was obtained from several comprehensive directories and listings (19, 21, 22, 23) and the publications of the Institution of Chemical Engineers, the Plastics and Rubber Institute, the Institute of Ceramics, and the Design Centre. The PICKUP computer-based directory was consulted initially, but contained extraneous information, and the classification system did not assist in the search for short courses at postgraduate level.

Although results in this section are presented as percentages, comparison with the results obtained from the questionnaire and interviews is not valid, and does not imply that supply matches demand. However, trends and preferences can be inferred: in this section the evaluations are qualitative rather than quantitative. The questionnaires and interviews were based on a representative sample (assembled from experience and judgement) of a total population of unknown size. However, the survey of courses and conferences includes nearly all those available.

The institutions providing courses were contacted by telephone and the course organiser questioned about how and why they ran short courses in materials-related subjects.

COURSES AVAILABLE WHICH COVER NEW MATERIALS

The survey shows that 165 courses were available over the two-year period, offered by 36 universities, polytechnics and professional institutions. The average length of course was three days, and attended by some 25 persons. By the method of 'double-counting' described above, these courses covered 322 'subjects'. This shows that on average a course covers two subjects as defined by Question 6 in the questionnaire. Examples would be a course on 'Joining Technology for Plastics and Composites', and 'Processing Technology and Product Development in Advanced Ceramics'.

A further 48 courses were found which met the needs expressed during the interviews, namely management, design and business.

ANALYSIS OF PROVISION

Table 6 shows the frequency of provision of subjects. Overall, the subject area most commonly offered was 'properties of materials-structure analysis' for composites.

Table 6: Provision of courses, in the UK, covering the four key material types - frequency of occurrence of subjects for 1988 and 1989

Subjects	*Plastics/ Polymers*	*Composites*	*Ceramics*	*Metals/ Alloys*
Properties	21	28	21	19
Processing technology	21	21	9	8
Joining technology	11	10	6	6
Product development	7	8	6	7
Marketing	4	7	4	4
General introduction	11	15	7	3
Detailed introduction	4	2	2	4
Environmental	—	—	1	—
Corrosion and wear	5	6	7	5
Surfaces and coatings	5	5	5	7
Total	89	102	68	63

Table 7: Course provision: subject distribution

Course Name	*% of 322 subject areas*
Properties of materials	28
Processing technology	18
General introductory course	11
Joining technology	10
Product development	9
Corrosion and wear	7
Surfaces and coatings	7
Marketing	6
Detailed introductory course	4
Environment	—

Most of the provision is in the analysis and determination of materials properties, and 'product development' in Table 7 shows low frequency (nine per cent), although this was the main requirement amongst questionnaire respondents. The mismatch between Tables 4 and 7 shows that provision of courses does not match the requirements of those who work in industry.

Ceramics as a course subject does not feature in the 1989 index of the Design Council Directory (19).

PROVISION OF CONFERENCES

Table 8 below shows the distribution of conferences through the materials types and location. This is included to complete the survey and to compare with course provision.

Table 8: Conferences covering New Materials, advertised in the UK, expressed as percentages of total conferences

Location	*Plastics/ Polymers*	*Composites*	*Ceramics*	*Metals/ Alloys*	*Total*
In UK*	9	10	7	6	32
In Europe	4	6	5	7	22
Rest of World	11	15	10	10	46
Overall	24	31	22	23	100

* Of the events in the UK, 15% were one-day events.

The distribution by material type reflects closely the interests expressed by the replies to Question 6.

ANALYSIS OF NEEDS AND PROVISION

This section examines the take-up of CET by the respondents to the questionnaire. Answers to Question 4 indicated that 87% of respondents had attended 196 working days in the previous 24 months, a quarter of which involved courses and seminars of less than one day's duration. Thus, as 24 months represent approximately 38,500 working days, the time expended on CET was just over one per cent of the respondents' working life of two years, about two days a year, half a day being spent at a course. Representing a quarter per cent, this falls very short of the two per cent recommended by the Engineering Council (EC) for CET (for course attendance).

Examining the replies to Question 6, there were 560 'requests' for CET. To meet this demand 280 courses must be provided (as most courses cover at least two subject areas as explained in Section 2). If each course lasts three days, this will require 840 days of CET courses. However, the needs for all respondents at the EC two per cent rate of their time will be 436 days. This shows that the needs are not being met. The replies to Question 6 mean that respondents would have to spend four per cent of their time on CET (about ten days per year).

HOW AND WHY COURSES ARE PROVIDED

Two-thirds of the universities and polytechnics named by respondents were contacted, and course organisers talked about the courses run in 1988, and those planned for 1989.

The age range of those attending the courses was predominantly 45 and under, but despite the earlier comments that courses were for 'young people', many participants were, in fact, of middle age.

Course lecturers and tutors were 57% from academic institutions, 41% from industry and two per cent lately retired from either. Some concern was expressed during the industrial visits about the possible relevance of the academics' knowledge of materials and their application in industry, but this was never raised in course feedback.

The courses were mainly promoted by advertisements in professional journals. A third of the institutions that responded used loose inserts in these journals - those who did not usually said they were 'too expensive'. The second most frequently used method is mailshots to a 'hot list', i.e. a list of persons considered likely to be interested in the event and expected to respond positively.

Speculative mailings to heads of departments and company training officers were favoured by about two-thirds of respondents. Word-of-mouth was used a bit - but is not a predominant line of communication. Courses are promoted in co-operation with an appropriate professional institution by two-thirds of the sample.

The opinions and activities of industries have been discussed previously. The telephone survey of available courses sought to establish whether the providers were really seeking to meet industry's needs, or simply offering what they can best provide.

The previous section shows that current supply and demand match closely - but whether this is cause-and-effect is not clear. Certainly, the courses are not self-indulgence by enthusiastic academics. For the most part, the opportunity of extra salary barely compensates for the additional workload. On the other hand, 63% of those interviewed said the courses were put on to make money for their department - and courses were only run if they could break even. Otherwise, 80% claimed they had perceived industry's need for the course, 50% had been approached by contacts, suggesting that a course on a particular subject might be run. Over two-thirds claimed that no other academic institution ran a course like theirs. Certainly the subject and content of the courses is dynamic - less than half the courses had evolved from earlier ones and just over half were ever repeated.

Did the courses meet the participants' expectations? Most organisers indicated that they had a system of evaluation at the end of the course, which led to more praise than criticism. Criticism seemed predominantly about human needs, and praise about the academic aspects. Table 9 shows the frequency of mention of these aspects.

Table 9: Features of short materials courses run in 1988 and 1989

Negative:	uneven emphasis	xxx
	poor food/too much wine	xxx
	poor venue	xxx
	expectations not met	xx
	under-subscribed	xx
	sessions too long	x
	lecturer's style	x
Positive:	balance of speakers	xxxx
	good accommodation	xxxx
	up to date	xxxx
	professional presentation	xx
	cheap	xx
	right level	xx
	nice staff	xx
	good discussion	xx
	good notes	xx
	adaptable	x
	informative	x
	local	x
	good equipment	x
	use of experts	x

The questionnaire also sought information about preferred group size. On the whole the respondents wanted a group size of 10-20. The courses investigated had an average minimum of 10 (in the range 2 to 30, though) and an average maximum of 25 (again in a wide range of 15 to 65). Where practical work was involved the maximum was usually less than 20.

New course development

INTRODUCTION

Using the information on the courses available together with the preferences expressed and job descriptions from Question 2, it has been possible to compile a tentative outline of the courses which would meet these needs. The 41 short courses set out in Table 10 are described in brief. The list must be interpreted qualitatively; it is not realistic to include proposals for details such as numbers of persons attending, locations or cost.

Detailed needs analysis should be carried out in each area by potential providers. This analysis should include the possibility of providing tailor-made courses (probably given in house) as well as the more commonly promoted open courses.

The reasons often given for not attending courses (and conferences) are 'pressure of work and time' and reluctance to be away from the workplace. Few companies contacted during this project had actually commissioned tailor-made courses to be delivered in house, yet several universities and polytechnics commented that they would be willing to prepare and deliver such courses. Closer liaison with industry and market research into this sector of CET would help to close another gap between needs and provision.

TERMINOLOGY

COMPANY CLASSIFICATIONS

The companies participating in the project have been classified under broad headings which are defined below:

Transportation

Design, development and manufacture of vehicles, automobiles, freight, rail, boats/ships, public transport.

Construction

Building materials, civil engineering.

Food

Production of food packaging and distribution, Fast Moving Consumer Goods (FMCG).

Aerospace

Design, development and manufacture of civil and military planes, airborne vehicles.

Components

Production of parts of larger items, assembled by others.

Equipment

Manufacture of complete items for the processing industry.

Materials

Manufacture of composites, plastics, polymers, ceramics, metals, alloys, in a form which is processed by others (i.e. their 'raw material').

Contract R & D

Trade association research establishments, independent laboratories, research and development companies.

Printing

Pigmentation of ceramics. (Printing on paper and other materials was not covered by this project).

Electronics

Design, development and manufacture of computers, computer peripherals, telecommunications and electronics in general.

Fuel Production

Supply, handling and use of solid, liquid and gas fuels.

HOW TO USE TABLE 10 (OUTLINE OF SHORT COURSES)

The courses are listed in decreasing order of the interest expressed in the combined questionnaire replies and visit interviews. Thus, 1 covers a subject of the highest interest and 41 the lowest. The order of the list was determined by calculating an 'interest-quotient' (IQ) in order to eliminate any bias due to numbers of respondents and/or companies in any particular industry. IQ is a function of the number of areas of interest expressed in Question 6 per person per industry-type.

These 41 courses are given solely as potential courses - and it is up to the judgement of course providers to determine whether any of these proposed courses could be merged or subdivided. For example it might be possible to merge courses 1, 2 and 3, or subdivide courses 34 and 35 according to material type, or promote course 37 as a follow-on to course 34.

Table 10 is constructed so that potential course providers can see:

- subjects of interest (COURSE NAME)
- likely market (INTERESTED INDUSTRY)
- which materials are of interest and their likely use in that particular industry (DESCRIPTION AND APPLICATION)
- who will be interested in attending the course designated by job description and/or qualification, based on replies to questions 2 and 12 (LEVEL)
- a very general proposal of course content (OUTLINE CONTENT OF COURSE)

Course 41 needs a special comment - Table 7 shows that current provision of courses is dominated by 'Properties of materials', and that 'properties' was the second most frequently cited subject of interest in the questionnaire responses. With this in mind, an outline proposal for a course on properties has been included despite the already seemingly adequate provision. All other courses have been selected on the basis of expressed high interest and low current provision.

Distribution of interest in courses in properties is evenly divided between managers, engineers, scientists and technologists. However, managers expressed interest in almost all such courses so, in general, they should be very responsive to courses on properties or materials.

ABBREVIATIONS USED IN TABLE 10

Cer	—	Ceramics
Comp	—	Composite Materials
FMCG	—	Fast Moving Consumer Goods
Met/All	—	Metals and Alloys
Plas/Pol	—	Plastics and Polymers
R & D	—	Research and Development
M	—	Manager of section or department directly and closely involved in materials use, application, development or production.
D	—	Director or head of division, with direct interest in materials.
E	—	Engineering qualifications or job description.
S	—	Science qualifications or job description.
T	—	Technologist by qualification or job description.
*	—	Denotes a senior position or with several years' experience in the technology.

Table 10: Outline of Short Courses

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
1. Product development	Transportation	Composite and Plastics and Polymers: Power Train	M E S T	Materials selection procedure — safety, reliability, testing — fabrication methods and skills — investment implication — maintenance — feasibility study — training needs.
2. Product development	Transportation	Composite and Plastics and Polymers: body and interiors	M E S T	As for 1.
3. Product development	Transportation	Composite and Plastics and Polymers: wheels, brakes, transmission	M E S T	As for 1.
4. Product development	Aerospace	Ceramics: engines, high temperature applications	M	As for 1.
5. Product development	Aerospace	Composite and metal alloys: body and wings — high temperature application	M	As for 1.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
6. Product development	Contract R & D	All material types	M D	Confidentiality — project scope and specification — joint projects — funding liabilities — ownership — buying and selling technology — legal aspects.
7. Product development	Materials manufacturers	Composite and Plastics and Polymers: lab scale to industrial production	E S T	Safety, reliability, testing — customer education — scale up — economics of introduction and replacement — field trials — fundamentals — trend spotting.
8. Product development	Components	Metals and Alloys	M D	Materials selection procedure — safety, reliability, testing — fabrication methods and skills — investment implication — maintenance — feasibility study — training needs.
9. Processing technology	Transportation	Composite and Plastics and Polymers: manufacture of vehicle parts	E T	Machinery — fabrication skills — safety — retraining — investment feasibility — design implications — raw materials — product handling.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
10. Processing technology	Food, other FMCG	Plastics and Polymers: Packaging	M	Product design — fabrication technology — health and safety in manufacture and use — versatility and reliability — materials selection, testing — properties specific to local environment — consumer education.
11. Processing technology	Materials manufacturer	Composite and Plastic and Polymers: new developments, future trends, current technology	M E* S* T*	Machinery — fabrication skills — safety and hazards — new developments, adaptability of equipment and processes — scale-up — future trends — product liability.
12. Processing technology	Aerospace	Composite: parts and components production	E S T	New and developing technologies — inter-relation of processing methods and properties — product design — relative merits of available technology.
13. Processing technology	Aerospace	Ceramics	E S T	As for 12.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
14. Processing technology	Contract R & D	Composite Materials	E S T	Fundamentals of materials handling and processing technology — project specification and management — interrelation of processing methods and properties — scale-up — design — legal aspects — liability — review of current and developing processes — safety and hazards.
15. Processing technology	Contract R & D	Ceramics	E S T	As for 14.
16. Corrosion	Materials production Contract R & D	All material types	M E S T	Assessment and measurement techniques — prevention and maintenance — causes of corrosion — design implications — aspects of joining technology — safety and product liability.
17. Corrosion	Fuel production Transport Aerospace	All material types	M E S T	As for 16.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
18. Ceramics	Fuel production Transport Aerospace	Developments in, and applications of advanced ceramics	M D	New developments — properties — applications — reliability — safety and hazards — use in diverse environments — compatibility with other materials — replacement implications — economics.
19. Ceramics	Materials production Contract R & D	Developments in, and applications of advanced ceramics	M S*	As for 18, including processing technology — product liability — marketing and customer education.
20. Introduction of New Materials	General	Economic implications — all material types	M D	Economics of change — feasibility studies — industry and public education — skills retraining — market research — product testing, liability and substitution — investment and finance — case studies.
21. Joining technology	Materials production	Composite and Plastics and Polymers: economics of change	M D	Science and properties of adhesives and bonding materials — economics and change — review of new and alternative techniques — safety and reliability — customer/client education — applications and use — skills retraining.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
22. Joining technology	Electronics	Composite Materials and Plastics and Polymers	M E* S* T*	Science and properties of adhesives and bonding materials — economics and change — review of new and alternative techniques — safety and reliability — customer/client education — applications and use — skills retraining.
23. Joining technology	Fuel production	Ceramics and Metals and Alloys: high temperature fuel use applications, fuel distribution	M	Safety and reliability — properties of adhesives and bonding materials — interaction with other materials — stability of joins under diverse and severe environments — testing and monitoring — skills requirements and retraining.
24. Joining Technology	Transportation	Composite: Vehicle and parts assembly	M	As for 21.
25. Languages	Transportation Aerospace Components Materials production Contract R & D	European languages, business methods and culture	M E* S* T* D	Spoken, written European language — scientific and commercial vocabulary and use — cultural briefing — business practice and procedures.
26. Surfaces and coatings	Electronics	All material types	M E S T	Outline of fundamentals of surface science — significance of surface properties — relation of properties to process technology — joining technology — surfaces preparation and modification.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
27. Management of technology	General	All material types	M D	Finance and budget management — staff recruitment and motivation — project specification — resources and equipment — development of ideas — joint projects — training and continuing education reward and recognition systems.
28. Surfaces and coatings	Contract R & D	Ceramics and Metals and Alloys	T S	As for 26 — with specific case studies.
29. Surfaces and coatings	Transportation	Plastics and Polymers Composite Materials	M D E S T	As for 26 — with specific case studies.
30. Marketing	Components	Ceramics	M D	Product definition — skills and training — market intelligence — market research — customer and public education — liaison with product development — legal aspects.
31. Marketing	Contract R & D	All material types	M D	As for 30.
32. Marketing	Materials production	Composite Materials	M D E* S* T*	As for 30.
33. Business methods	General	All material types	M D E S T	Forms of contract — legal aspects — taxation briefing — European (and other) business outlines export/import procedures — foreign exchange — sources of finance — employment law.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
34. General introduction to new materials	Transportation and aerospace Fuel production	All material types	M D	Definition and general properties — implications of introduction of new materials (financial, personnel, skills) — product design and integration — strategy for marketing and customer education — testing and wear — safety and environmental aspects.
35. General introduction to new materials	Contract R & D	All material types	M D	As for 34.
36. Design with new materials	Transportation Aerospace Components Materials production Contract R & D	Integration of material and design — all material types	M D	Materials selection and specification — design/function relationship — processing technology — industry and public education — economic implications — product liability.

Course Name	*Interested Industry*	*Description and Application*	*Level*	*Outline Content of Course*
37. In-depth introduction to new materials	Fuel production	All material types	E T	As for 34, with more depth in some areas to make an appropriate foundation for further detailed courses.
38. Environment and new materials	Food, printing and FMCG	Plastics and Polymers: packaging use, production and disposal	M E* S* T*	Implications of disposal of production waste — safe production procedures — product testing — field testing — product safety — social aspects — economics — legislation — consumer education.
39. Environment and new materials	Transportation Equipment manufacturers Construction	All material types	M D T*	As for 38 — with particular reference to long-term aspects.
40. Environment and new materials	Materials producers Contract R & D	Composite materials	M E S T	As for 38 — with particular reference to legislation and liabilities and responsibilities.
41. Properties of new materials	Materials producers Transportation Fuel production	All materials types	M E S T	Structure, analysis — prediction — equipment and techniques for measurement and testing — implication of properties — stability.

Continuing review of needs and provisions

The third aim of the project covered recommendations regarding the establishment of a system to review the ongoing CET needs of the materials industry.

A review system of CET in new materials must cover two aspects:

What are the needs?
Does the provision meet the needs?

REVIEW OF NEEDS

Whilst a monitoring system of course take-up will show use and interest, it cannot determine fundamental needs. These can only be established by systematic surveys of the activity and development of the industry. The surveys could take several forms:

- personal interviews of selected representatives of key industries, at regular intervals
- personal interviews but randomly selected on a continuous basis
- questionnaires sent out, at regular intervals, to named individuals
- questionnaires published in the relevant professional journals
- combining the elements of such a survey with the already established pilot scheme of the Engineering Council (20) which is monitoring engineers' career development

Whatever method is used, effective reviews must include the opinions of individuals in a representative sample of industries, and the time interval between reviews must be appropriate. Too frequent, and trends will either not be discernible or be misleading; too seldom, and the provision of courses will cease to match needs. Furthermore, to allow the courses themselves to help establish whether a repeat is relevant, the review of needs should not be less than biennial.

It is also important to establish a time-scale for a review system which allows for the beneficial use of hindsight and development of a good sense of perspective on industrial trends.

The proposed survey could be based on, and developed from, the system used in this project. At least one person should be delegated to take responsibility - the industrial liaison officer in one of the professional institutions, with a close interest in the materials industry, might be appropriate.

REVIEW OF PROVISION

There are two main reasons for reviewing the provision of courses.

Firstly, for courses in particular, were those who attended completely satisfied and will the course need any modification if it is to continue to attract students? The aspects which have to be monitored are:

accommodation	written material
food	level (= intensity)
organisation	peer group
cost	promotion
content	publicity
speakers/presenters	credibility
style	relevance
location	topicality
size	briefing
participation	purpose

Almost every course organiser issues an evaluation document to the participants at the end of a course - asking questions which cover (in part) the items above. The replies assist in keeping the courses on offer relevant and attractive.

Secondly, a wider view of courses in general is necessary, covering the provision of CET - in the form of an overview of course (and conference) provision year by year throughout the UK. Although several course directories already exist, none contains all the courses on offer which are relevant to the needs of the New Materials Industry. The provision of a comprehensive course directory by at least one of the relevant professional institutions (or a consortium) would greatly help in making an overview and evaluation of the annual provision of courses. This could take the form of a guide which includes relevant extracts from existing directories. There is currently no mandatory system for the notification of course provision.

However, production of such a directory implies potential users will seek it out to acquaint themselves with what is available. This project has established that current practice amongst materials scientists is principally passive attention to advertisements in professional journals for courses and similar CET events. For this reason the professional institutions should be more active in stimulating a positive search and take-up of CET by individual scientists.

At least one person will need to take full responsibility for the production of such a directory, possibly the same person responsible for the 'review of needs' identified earlier.

This person might be sponsored by a consortium which could include, e.g. the Institute of Metals, Institute of Ceramics, Institution of Chemical Engineers, Design Council, Engineering Council, Department of Trade and Industry and the Department of Education and Science.

The scope of such a project would have to include a comprehensive system of compilation, the distribution of the directory, and incentives for contributors and users alike to make it successful. Furthermore, the scope should include provision for a survey and analysis of courses on offer. The timetable of directory publication and such an analysis would have to be carefully planned, in order to make both exercises meaningful.

Conclusions

FORM

1. CET in new materials has many forms. For postgraduates it includes:

   - interaction with universities/polytechnics in the form of research projects
   - conferences and seminars
   - interaction and collaboration with other industrial companies
   - in-house events, e.g. informal seminars and lectures by staff or invited external speakers
   - interaction with professional and trade associates

- courses in specialist subjects
- interaction with colleagues and contacts in other companies and institutions
- consultants and exhibitions

2. Conferences and symposia (of not more than three days) are the most commonly used form of CET. Short courses (one or two days) are stated to be the second preference although they are not the second most often-used method.

3. Many respondents indicated a dislike for commercial organisations who put on CET events 'solely for profit'.

ROLE AND PURPOSE

1. Participation in any form of CET is not normally part of any assessment for promotion as respondents indicated that they are judged on performance. A small proportion of those interviewed had to write scientific papers for career reviews.

2. CET is principally seen as an activity which benefits the industry.

3. Close co-operation between industry and academia is valued highly in joint projects and in courses and seminars.

4. Skills such as flexibility and adaptability are rated very highly by employers.

CONTENT

1. Informal events are most favoured, with the opportunity for discussion and questioning.

2. There should be an accurate description of proposed events. The level of material and type of person expected to attend are usually not described clearly enough.

3. Intense cramming courses were thought to be counter- productive. Adequate time for thinking and talking did not feature often enough in course design.

4. The main areas in which respondents wanted to see more CET were:

   composites
   ceramics
   polymers
   alloys
   introduction of new materials
   product development
   properties and processing technology
   corrosion and joining technology
   management of technology
   business methods (including those of foreign countries)
   a European language (and understanding of other cultures)

5. Emphasis of demand in subject matter is not matched by the supply. Product development is the main interest of industry, however, most courses offer Properties of Materials.

PROVISION

1. Enthusiasm and interest in CET confirm that a large need is not being met either in quantity or content.

2. Consideration of the current use of courses (and their provision) with the stated interest leads to the conclusion that to meet the Engineering Council recommendation for two per cent CET at the current take-up pattern, the provision of courses must be doubled.

However, the expressed interest in CET (as courses only) was four per cent, so to meet this demand, the figure must be increased by a further factor of two.

3. The materials profession used about 165 courses that were available in 1987 and 1988 in 37 institutions. To meet the four per cent interest in CET, each educational institution which currently offers courses would need to make another three courses available. It was not possible to confirm whether the institutions have the staff and facilities to make such provision.

4. Publicity for CET events - courses in particular - is rather haphazard and unregulated. Even major directories are not all-inclusive, and most professional institutions could play a greater role in systematic promotion of courses.

5. Most provision is for properties of materials.

6. There is relative over-provision of courses based on plastics and polymers, and under-provision in ceramics and metal/alloys.

7. To meet the demand and interest in continuing materials education, a wider range of short courses should be devised and targeted at carefully selected segments of industry.

8. The developing training needs of industry should be reviewed every two years.

USE

1. Time off and funding for attendance at CET events have not been major problems Only a minority of employees are required to make a formal justification before release is permitted.

2. Responsibility for their CET in new materials falls to most respondents as individuals. A small proportion share the responsibility with their employer.

3. There is much concern about long-term stimulation of young engineers and scientists to develop their careers, and that pay levels are such that graduates in the materials disciplines are easily attracted to careers in other areas.

4. Younger engineers and scientists do not participate in CET events to the same extent as their older colleagues.

5. Overall current participation in CET in materials is one per cent of a working year - attendance at courses representing about a quarter of this.

6. Attitudes to CET in materials are positive with keen support for the aims of this project.

7. The greatest interest in CET in materials-related work was shown by employees in transportation, food, fuel, contract R & D and electronics industries.

Recommendations

SUBJECT MATTER

1. CET is most urgently required in the following areas:

Composites	*Ceramics*	*Metal/Alloys*
Product development	Product development	Product development
Joining technology	Processing technology	Corrosion
Corrosion	Corrosion	Surfaces
—	Joining technology	Joining technology

   Provision of courses covering plastics and polymers is a lesser priority.

2. CET events which cover introduction of new materials, management of technology and business methods are also required to meet the needs of industry.

3. There is a demand for European language courses, including coverage of other European cultures and business methods.

STYLE

1. Conference or seminar-type events are preferred to formal conventional courses.

2. Particular attention should be paid to group size - around 150 for a conference and around 20 for a course.

3. Courses should avoid cramming, and all CET events should include ample discussion and question time.

4. Length of events should be one to three days.

5. There should be higher standards of catering, accommodation and human comforts for CET events.

6. The market for provision, content and delivery of tailor-made courses should be further researched.

PROMOTION AND PUBLICITY

1. Particular attention should be paid to the promotional material, which should describe the level of the course and the target audience.

2. Papers and materials presented at conferences and seminars should be more systematically vetted and refereed to ensure accuracy, topicality and originality.

3. Providers should make more frequent use of the staff and resources of the professional institutions to promote and/or sponsor the events.

4. A comprehensive directory of courses relevant to materials should be produced annually. Its compilation and use should be carefully monitored and its effectiveness evaluated after an appropriate time interval.

5. To run courses to meet the stated demand, financial assistance will be necessary. More industrial sponsorship will reinforce relationships between industry and academia. Also, involvement of industry in the provision of training - e.g. by secondment of staff - will help ease the burden which will fall on the providers of courses and ensure relevance and topicality.

6. Courses should be devised for, promoted and marketed specifically within particular industries - notably in transportation, food, fuel, contract R & D.

7. The establishment of a continuous monitoring system to review the needs of materials-related industries for CET, administered by at least one designated person within the professional institutions would serve to ensure that provision and needs are reconciled.

8. Such a monitoring system could be based on the work of this project. The frequency of review should be about every two years.

9. Promotion of more events specifically aimed at young, recent graduates will help to satisfy the disquiet expressed about opportunities for their career development.

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Appendix: Visits — topics for discussion

1. *Company profile*

   Products - materials - markets. Resources and technology - manpower - skills. Support skills - recruitment - consultants - secondment.

2. *Continuing Education - policy*

   Staff versatility - adaptation - lateral skills. In-house courses and on-the-job training. Policy statements on continuing education. Time off and funding - management involvement.

3. *Continuing Education - attitudes*

   Purpose - recognition - motivation - rewards - career development and structure - flexibility and adaptation - age and qualifications - active *v.* passive interest.

4. *Continuing Education - availability*

   Sources - take-up - preferences in style and content - omissions - criticisms - needs - co-operation with suppliers of CE - awareness of material.

5. *Future plans*

   Industry trends - implications of 1992 - competition and development - relation of industry with academia. Skill weaknesses and shortages. Technology trends.

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